EIC Detector R&D Progress Report: R&D Proposal for 10 Picosecond TOF PID at an EIC

From Jan 2014 to July 2014

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Progress Report Past

What was planned for this period?

We had originally planned to begin development of a PSEC4 based readout system, and to start developing a design based on the Incom LAPPD MCP-PMTs. In addition, we were interested in starting simulations to demonstrate where a TOF PID system benefits an EIC detector, particularly in relation to how it fits in with other PID detectors, such as a RICH.

What was achieved?

The UIUC group has embarked on simulations to demonstrate where a TOF PID system contributes in the overall physics program of the EIC, especially with regard to how it fits in relation to other PID detectors, such as a RICH. Essentially, since the RICH detectors need to have high momentum reach, they will necessarily have a relatively high threshold before particles will register in the RICH. For instance, the RICH proposed in RD2011-6 has thresholds of about 4, 15, and 28 GeV for the pi, K, and p, respectively. A TOF system would neatly complement such a RICH detector, provided it had resolution of about 10 ps, which would allow the TOF to cover the lower momenta without taking much of the valuable space. To demonstrate where the TOF contributes, UIUC has looked into the measurement of transverse Collins and IFF spin asymmetries.

A graduate student, Yakov Kulinich, and two undergraduate students, Chong Han and David Hjelmstad, have started at UIUC in April 2014 to study the possibility of transversity distribution measurements with psTOF added to an EIC detector. The goal is to establish the feasibility of a physics program that aims at a rigorous extraction of quark- and antiquark-transversity distribution and from this an experimental determination of the tensor charge. The experimental result for the tensor charge then can be compared to the determination of the tensor charge based on lattice QCD. As a first step towards this goal, transverse spin asymmetries have been added to PYTHIA and simple response functions for the RICH and TOF detectors was implemented: pion threshold, $p_{thresh} > 5$ GeV, and a kaon threshold of 15 GeV. TOF pi-K separation up to 6.6 GeV and K-p separation up to 11.1 GeV. The UIUC group has also gained permission to use the NCSA Blue Waters supercomputer on the UIUC campus to significantly increase the computing capabilities at their proposal:

http://www.ncsa.illinois.edu/enabling/bluewaters

A search for a post-doc, 0.5 FTE supported by EIC R&D funds, was initiated in March. Ihnjea Choi was hired, with a start date of July 1, 2014. The UIUC graduate students are fully funded by UIUC. Ihnjea will begin by looking into setting up the EIC simulations on Blue Waters.

What was not achieved, why not, and what will be done to correct it?

Our original proposal was to develop a full system prototype of a MCP-PMT TOF detector based on the commercially produced Incom LAPPD and using the PSEC5 ASIC, which would have been capable of being used in a collider environment like the EIC. In the first year we intended to develop the readout electronics based on the currently available PSEC4 chip, which is similar to the PSEC5 except that it has too short a buffer to be usable at the EIC.

The EIC R&D committee recommended that we restructure our proposal since it was unlikely that the PSEC5 ASIC would be available on any reasonable time-table. In addition, the Incom LAPPD tiles would be delayed by at least half a year from the original schedule.

Fortunately, a nice opportunity was provided to us when Argonne joined as a major part of our collaboration. Argonne has made available their LAPPD small tile production facility to produce 6x6 cm^2 MCP-PMTs. These are actually much more appropriate for R&D geared towards improving the MCP-PMTs. BNL and the university groups will work with them to modify the standard LAPPD MCP-PMTs to better suit the needs of the EIC detectors, in ways that would have been difficult to do with the Incom LAPPD MCP-PMTs. At

Incom, they are interested mostly in developing the processes to commercial produce MCP-PMTs reliably and at low cost, and therefore they are not as receptive to modifications of the MCP-PMT design. More details of the changes to our plan can be found at the proposal that we submitted for the July 2014 EIC R&D meeting.

https://www.phenix.bnl.gov/WWW/publish/chiu/pstof/EIC/PSTOF_EIC_July2014.pdf

Future

What is planned for the next funding cycle and beyond? How, if at all, is this planning different from the original plan?

We have restructured the proposal to align it more within the intent of the EIC R&D program. In the specific case of our group, this will be to do R&D to improve the state of the art for a couple of promising technologies for very fast timing detectors, at the level of 10 picoseconds or better. Our group intends to study and improve upon both the LAPPD MCP-PMT detectors as well as glass mRPCs, both of which have been reported to achieve close to 10 picosecond resolution. Either of these technologies could form the basis for a very high resolution Time-of-Flight detector for particle identification at an EIC. More details can be found in the proposal we submitted for the July 2014 meeting, which can be found at

Starting in July, Ihnjea will assist in implementing a GEANT based detector simulations on either the new UIUC campus cluster or the Blue Waters supercomputer at NCSA in Urbana. This study is expected to have final simulation results on quark transversity distributions, including the sensitivity for anti-quark transversity distribution and the strange transversity distribution by the end of 2014. It is then planned to study EIC sensitivities for momentum- and helicity-distributions. Beyond the studies that are already available for momentum- and helicity-dependent distributions we aim to investigate the capabilities at EIC to measure the p_T dependence of distribution functions and fragmentation functions.

In addition to the LAPPD MCP-PMT R&D mentioned above, UIUC, BNL, and Howard will do R&D on improving mRPC technology for timing purposes. First we will try to reproduce a reported resolution of 16 ps for a 24 gap mRPC, and then try to improve upon that through use of different reconstruction techniques, smaller gaps, different gases, and changes to the materials used to construct the mRPCs. Howard will work on simulations of the mRPC detector to guide our development, informing us which gases are reasonable to try, and to better help us to understand the factors which determine the timing resolution in mRPCs.

What are critical issues?

None at the moment.

Additional information: